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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

February 24, 1999

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
445 12th Street, S.W.
12th Street Lobby, TW-A325
Washington, DC 20554

Re: Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems, CC Docket No. 94-102.

Dear Ms. Salas:

On February 24, 1999 Michael Amarosa, Louis Stilp, Antionette Cook Bush, and I, on behalf of TruePosition, Inc., met with Thomas Sugrue, James Schlichting, Robert Calaff, and Daniel Grosh of the Commission's Wireless Telecommunications Bureau. The discussion centered on the Bureau's Public Notice of December 24, 1998 and the Commission's desire to maintain a technology neutral policy while promoting the public safety benefits of wireless E911. Attached is a copy of the handout used during the discussion.

In accordance with the Commission's rules, we are submitting two copies of this letter.

Sincerely,

Philip L. Verveer

cc: Thomas Sugrue
James Schlichting
Robert Calaff
Daniel Grosh

No. of Copies rec'd 0+2
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Presentation to FCC
February 24, 1999

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Wireless Location System

Overview

- ▲ **Wireless Users Want E9-1-1 Location Services By 2001**
  - **Majority Want E9-1-1 Location To Apply To *All* Phones**
- ▲ **Current Rules Are Technology Neutral and Were Issued In Sufficient Time For Technology Development**
- ▲ **Differences In Measurement Methodology Creating Misperceptions About Location Accuracy**
- ▲ **Uncertainty Causing Delay in Rule Implementation**
- ▲ **Network Solutions Work Today**
  - **Analog, TDMA, CDMA, PCS**
  - **Rural Areas**
  - **Low Technical Risk and Low Cost To Implement**
- ▲ **TruePosition System Successfully Deployed In Houston**

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Accuracy Today Meets FCC 125 Meter RMS Requirement

- **Significant Deployment Experience in Top 5 U.S. Cities**
  - 125 Sites, 2,000 Square Miles, Coverage: Downtown, Dense Suburban, Suburban, Rural, Water
  - 70 Sites, 300 Square Miles, Coverage: Downtown, Dense Suburban
  - No Changes To Antennas or Cellular System Parameters
  - No Changes To Mobile Phones
  - Locating Over 10,000 Indoor and Outdoor Test Calls Per Day
  - Over 1,000 Well Distributed Test Points
  - Locating Over 3,000 Wireless 9-1-1 Calls Per Week
- **Network of Indoor Permanent Test Phones: 80 Meters RMS**
- **All Tests Over Wide Areas: 100 to 125 Meters RMS**
  - Alternate Measurement: >67% of Calls Have Accuracy <61 Meters
  - Alternate Measurement: >44% of Calls Have Accuracy <30 Meters

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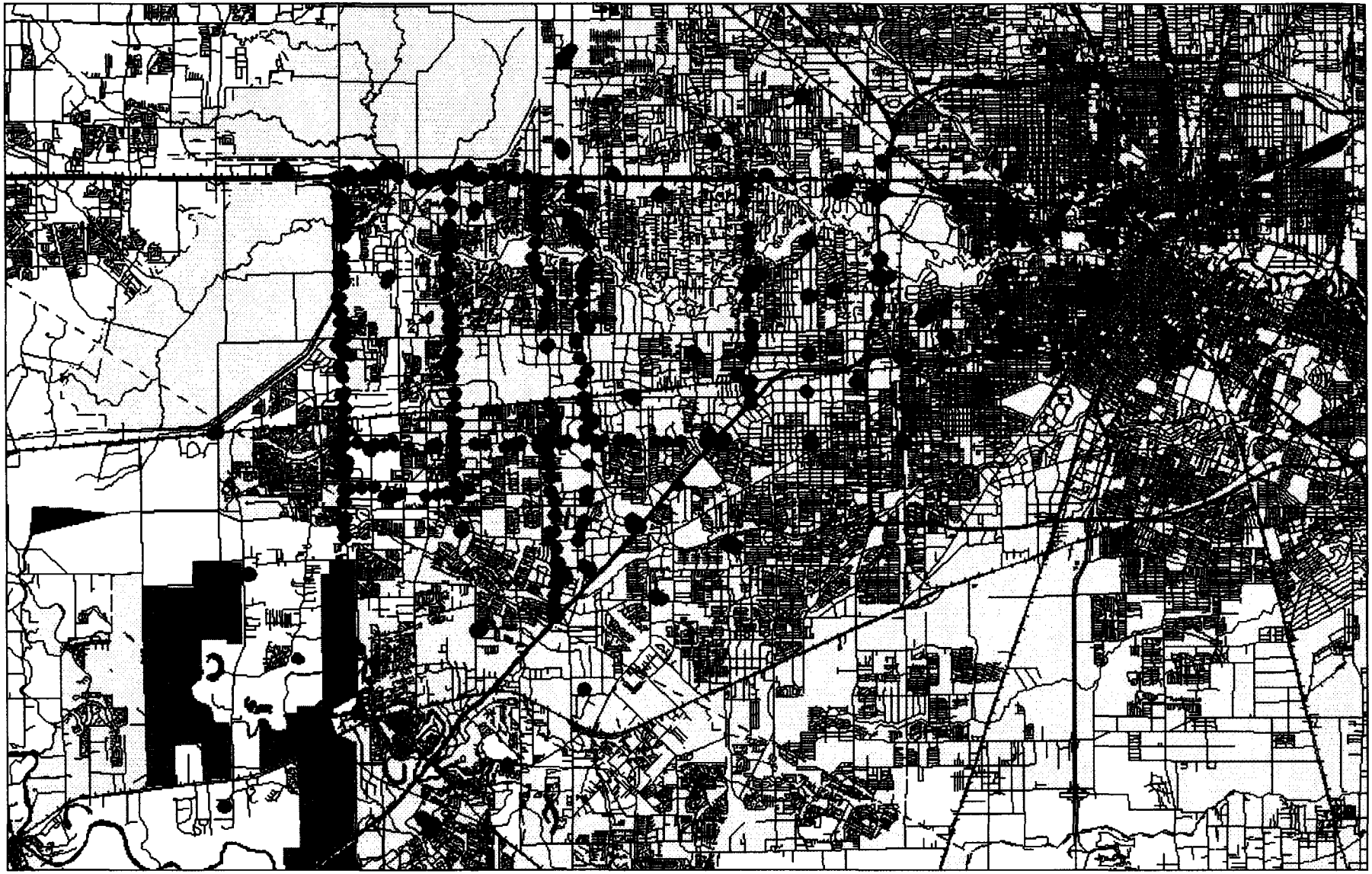
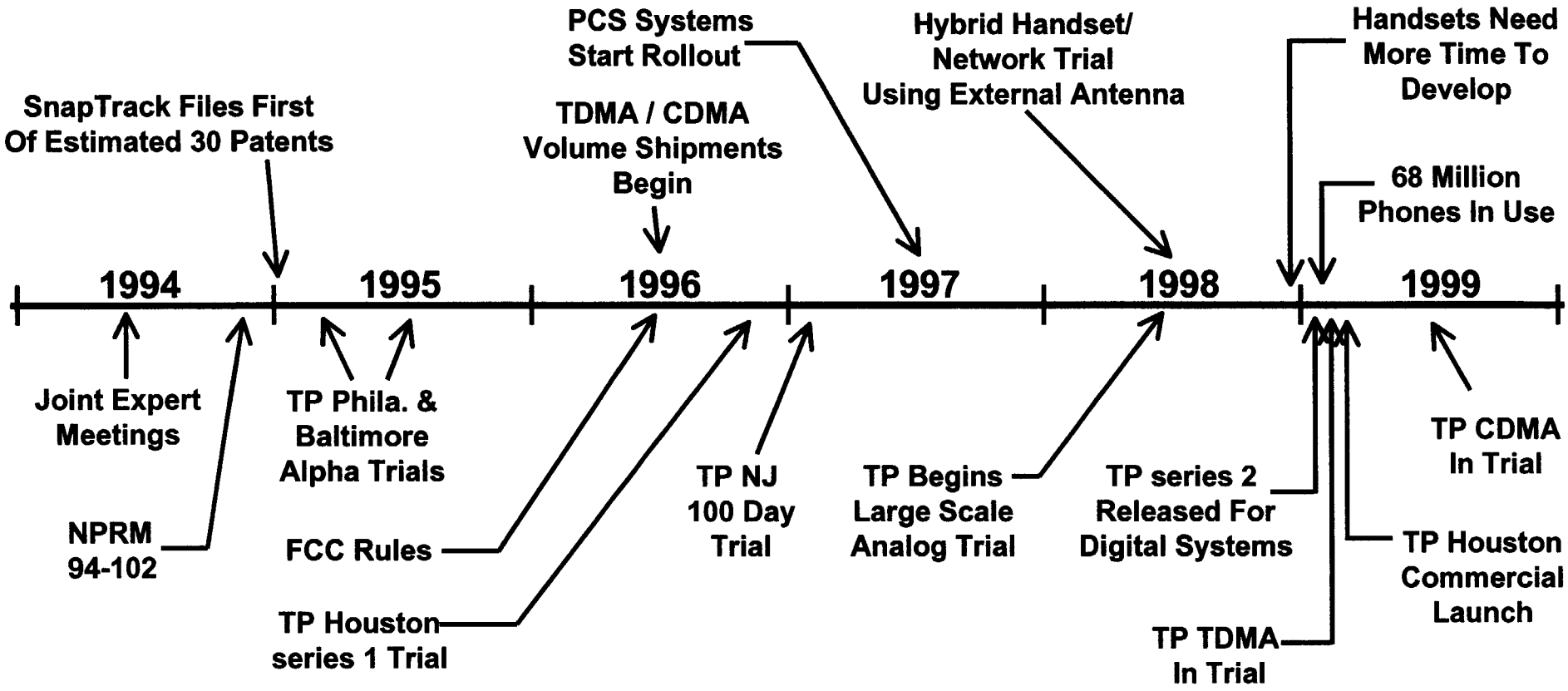
Test Using Standard AMPS Phone - Houston



A Tale of Two Technologies



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Questions to Compare Accuracy Objectively

- **Actual Handsets and Cell Site Equipment?**
  - ***Significant*** **Difference Between External and Integrated GPS Antennas**
- **Reference For Comparing Accuracy of a Measurement?**
  - **With GPS to GPS Comparison, Both Drift Simultaneously**
- **Error Calculation Methodology?**
  - **RMS, Standard Deviation, and 67% Produce *Very* Different Results**
- **Number of Test Points Over How Large an Area?**
  - **Always Good and Poor Areas, Combine Many Points Over Wide Area**

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Factors To Accelerate Deployments and Improvements In Location Accuracy

- **Cost Recovery**
- **Limitation of Liability For Wireless E9-1-1**
- **Unambiguous Guidance From FCC**
- **Increased Field Testing In More Cities**
- **Integration Between Wireless and Location Systems**

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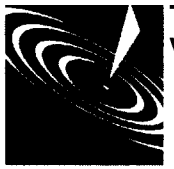
Dollar Cost Factors To Consider

▲ Favorable Trends For Network Based Costs

- One Receiver in Cell Site, Independent of Number of Phones
- Location Systems Can Be Shared Between Multiple Carriers
- Subscriber Density Per Cell Site Increasing, Reducing Average Cost
- Easier To Upgrade 50 to 60 Thousand Cell Sites Than 68 Million Phones
- Integration Into Base Stations Will Help Reduce Costs

▲ Implications For Hybrid Handset / Network Based Costs

- New Replacement Phones Required For Everyone
- Many Patents From Single Vendor Could Result In Large License Fees
- Every Churned GPS-Enabled Phone Wastes Cost Recovery Money
- Incompatible Approaches May Lead To Duplicate Systems Per City
- Networks *and* Handsets Must Be Changed
- Estimated $3 Billion To Replace Just 20% of Handsets (Ameritech)



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Accuracy Determinants of Location Systems

- **Applies To GPS, Network, Handset Approaches**
- **Transmitted Signal Characteristics**
  - **Effective Signal Bandwidth**
  - **Signal to Noise Ratio**
  - **Integration Time**
- **Environment (i.e. Terrain, Clutter)**
  - **Propagation Characteristics**
  - **Multipath**
- **Receiving Equipment and Processing Algorithms**
- **Transmit or Receive Geometry**

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How Accuracy is Measured is Important

- **TruePosition Surveys Reference Test Points**
  - **Using Differentially Corrected GPS, Averaged Over 15 to 30 Minute Interval**
  - **Surveys Are Repeated Over Time To Remove GPS Induced Errors**
- **Many Test Calls Made on Multiple Days From Same Test Points, Using Different Test Drivers**
- **Standard Handheld Phones, Typically Used Inside Vehicles**

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RMS is Not The Same as 67%

Location Errors

131 Feet	x 131	=	17161
217	x 217	=	47089
343	x 343	=	117649
380	x 380	=	144400
492	x 492	=	242064
609	x 609	=	370881
	Average	=	156541

Root Mean Square (RMS) = √ Average = 395 Feet

67% Point = 380 Feet

- Different Measures Of Error Spreading
- FCC Requirement Is RMS

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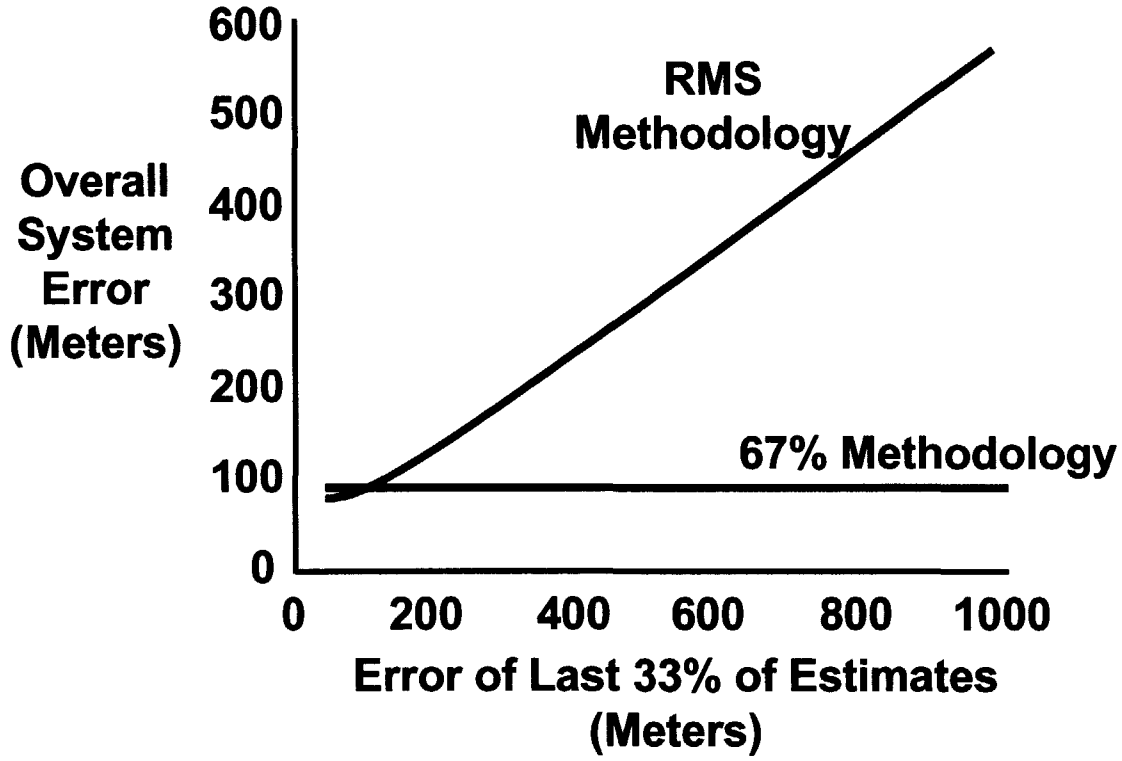
Why RMS Is More Important Than 67%

Overall Location System Error
Assuming Error of First 67% of Estimates Is 90 Meters



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67% Methodology Has Limitations

- **67% Methodology *Hides* Error Magnitude of Last 33% of Location Estimates**
- **Typical U.S. Cell Site Spacing Is 8,000 To 20,000 Meters**
  - **Phase I Errors Typically 3,500 To 8,000 Meters (2.1 To 4.8 Miles)**
  - **Even Small Percent of Phase I Errors Has Large Effect On System Error**
- **RMS Methodology Forces Location System to Make Good Estimates of *All* 9-1-1 Calls For *All* Phones**
  - **FCC Made Right Choice For Public Safety**

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Network Based Systems Have Many Opportunities For Accuracy Improvements

- **Increasing Effective Signal Bandwidth**
  - Consecutive Location On Both Control and Voice Channel
  - Signal Manipulation Coordinated With Location System
  - Multipath Changes With Channels, Allows Statistical Averaging
  - Increased Bandwidth Improves Multipath Resolution
  - Digital Signals Have Greater Bandwidth Than AMPS Channels
- **Increasing Effective Signal to Noise Ratio**
  - Dynamic Channel Allocation Assigns "Cleaner" Channels
  - "Flexible" Digital Control Channels Reduces "Collision" Probability
  - Brief Power-up Functions Only When Necessary
- **Increasing Integration Time**
  - Digital Phones Have Lower Phase Noise
  - Station Based Processing Permits Increased Integration Time

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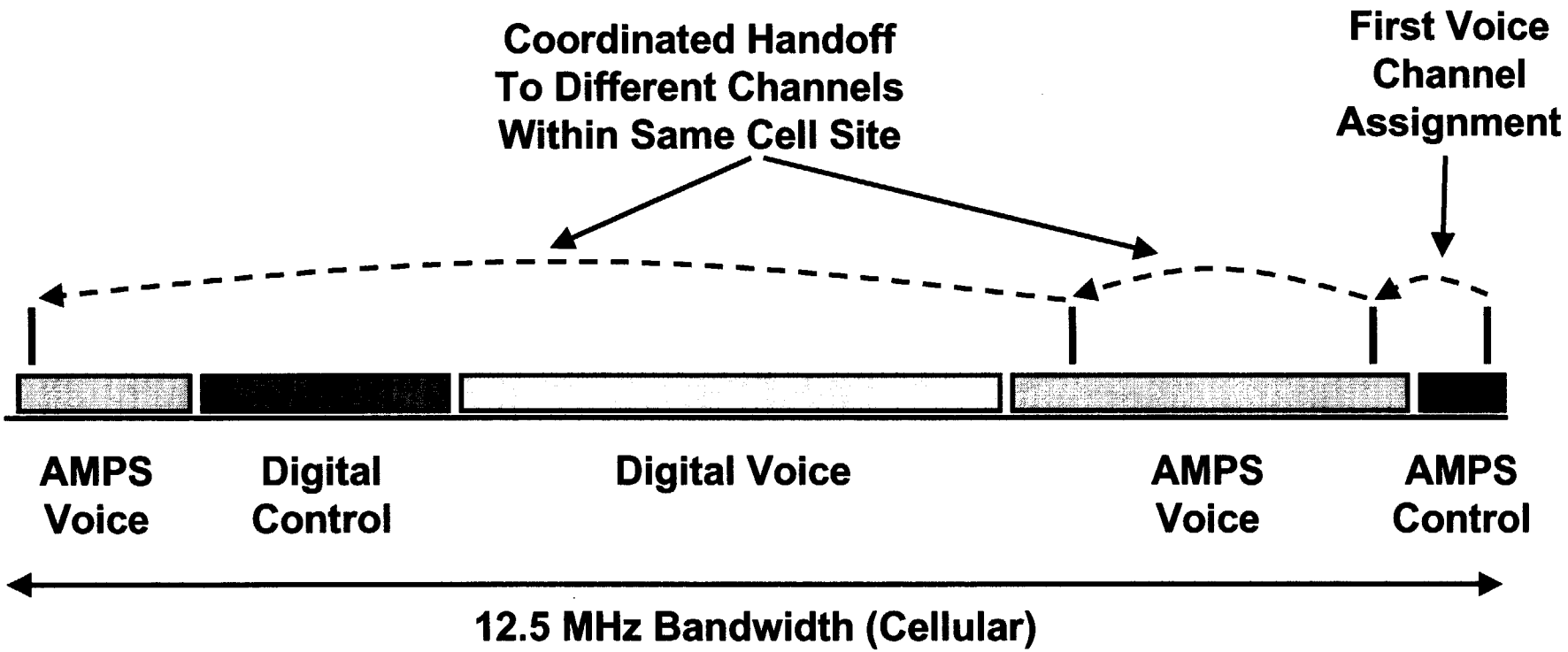
Synthesizing Increased Signal Bandwidth: How To Turn KHz Into MHz



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Potential Synthesized Bandwidth Can Be Much Greater Than Even GPS

- **Uses Existing Wireless Telephones**
  - **No Changes To Air Interface Standard**
- **Telephone Transmitted Bandwidth Remains Constant**
  - **AMPS is 20 KHz, For Example**
- **Location System "Synthesizes" Increased Effective Bandwidth With Each Change In Channel**
  - **Effective Bandwidth Potential Is 10 MHz to 12.5 MHz**
  - **Technique Requires Coordination, and Has Limitations**
- **Even Without "Synthesis", Multipath Processing Ability Improves With Each Change in Channel**

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Network Support for Rural Areas

- **Favorable Signal Characteristics**
  - Reduced Signal Loss
    - » Generally Flatter Terrain With Low Building Density
    - » Generally Taller Cell Sites
  - Significantly Reduced Multipath
  - Significantly Reduced Interference From Other Mobiles
- **Tower Sharing Improves Coverage**
  - System Design Includes Cell Sites From More Than One Carrier
  - Supplementary Receivers at AM/FM, Paging, Police/Fire Towers
- **When Needed, Additional Antennas at Cell Sites**
  - Improved Processing Gains
  - Combine Direction and Time Measurements
  - Permits Location With Only Two Cell Sites

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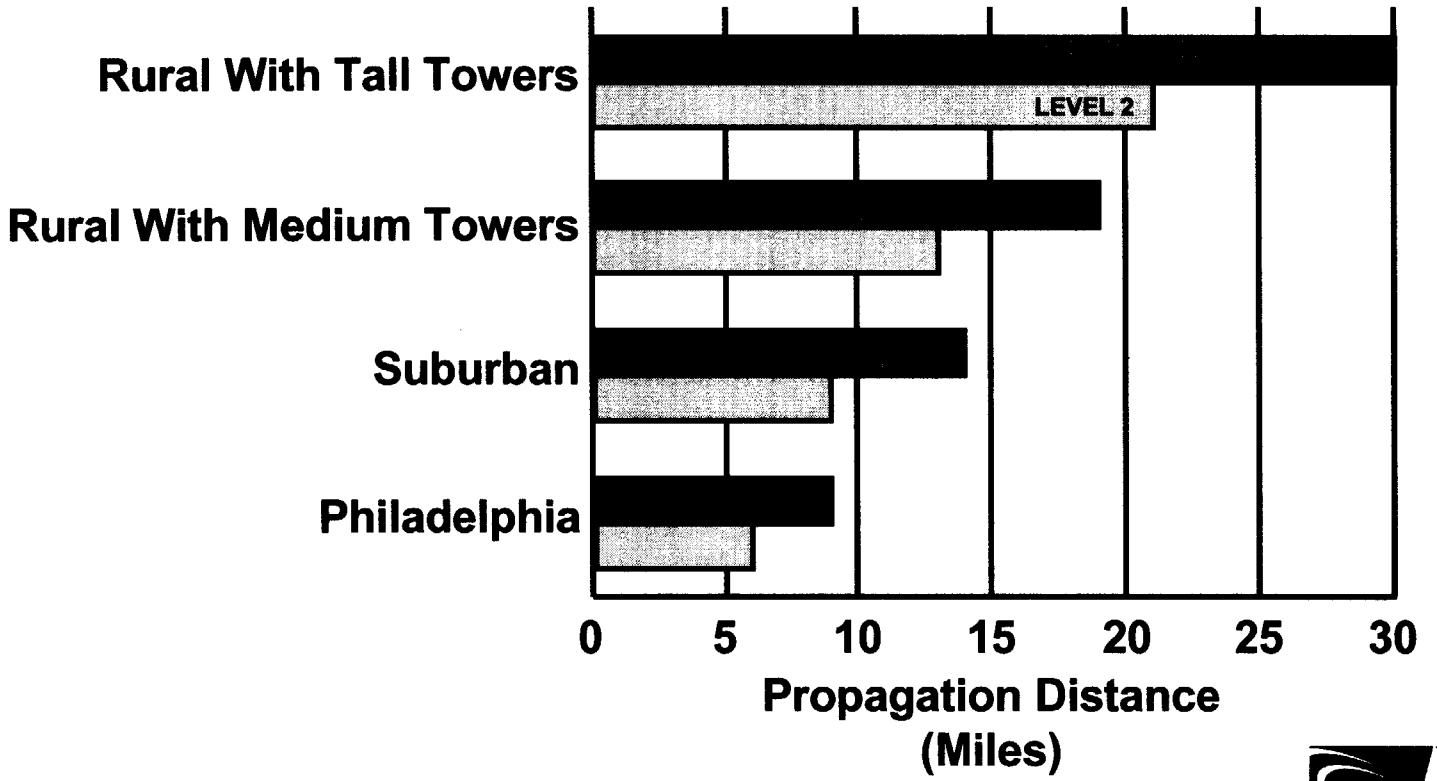
Reduced Signal Loss In Rural Areas Means Greater Propagation Distances

Comparative Propagation Distances
At Two Example Equivalent Received Signal Levels



Source: *Mobile Radio Propagation Channel*, J.D. Parsons

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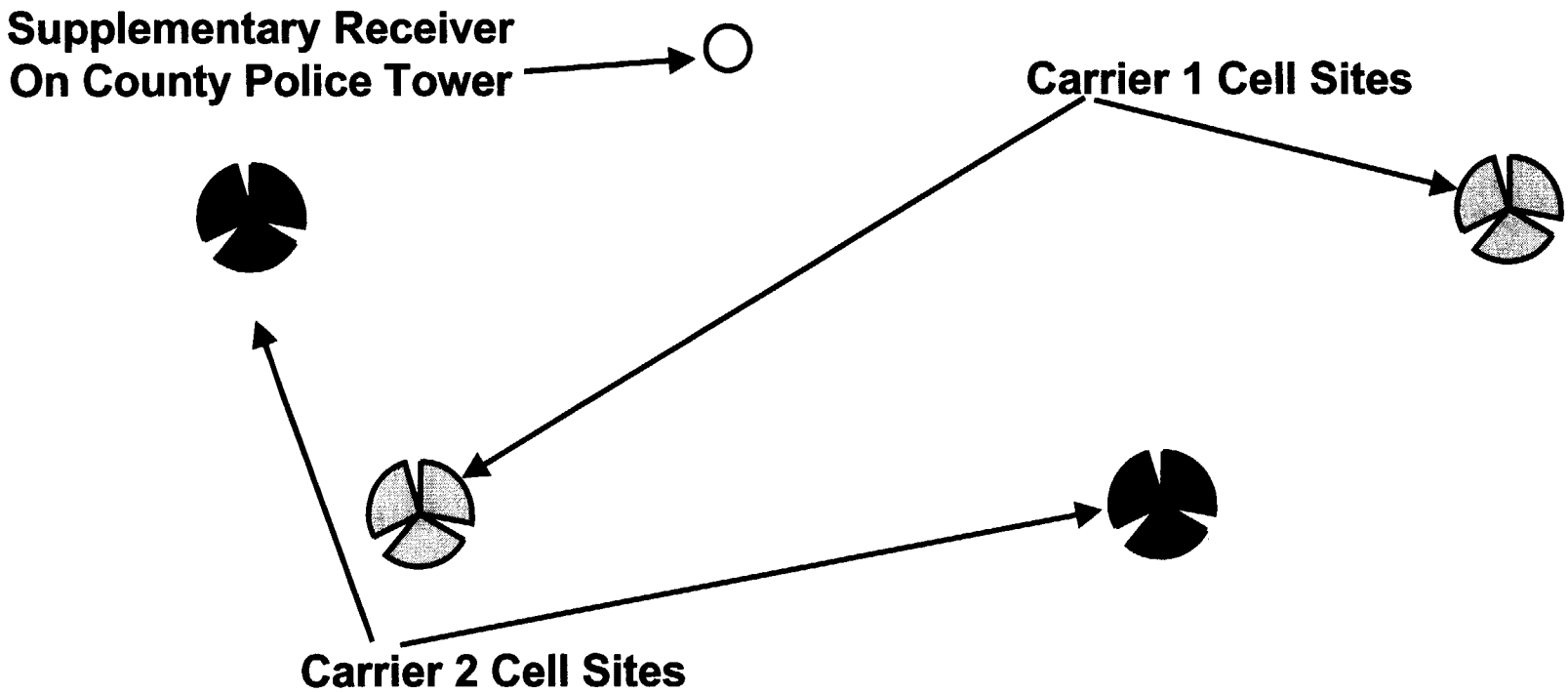
Sample Rural Design Using Shared Towers



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Tower Sharing Is Low Cost and Minimal

- **Location System Receivers**
  - Compact Size and Low Power
    - » Capable of Indoor / Outdoor Mounting
  - Receive-only and Non-interfering
  - Multi-band Support (i.e. Two Carriers Supported Simultaneously)
- **Receive Antenna Requirements**
  - Use Existing Antenna at Cellular / PCS Towers
  - Minimally Invasive 3-dB Omni Antenna at Non-cellular / PCS Towers
    - » Far Lower Requirements Than Cell Sites
  - Can Be Installed at Many Structures In Addition To Towers
- **No Reason To Expect New Tower Construction**
  - Currently More Than Existing 65,000 Cell Sites In U.S.
  - More Than 250,000 Other Possible Sites To Consider

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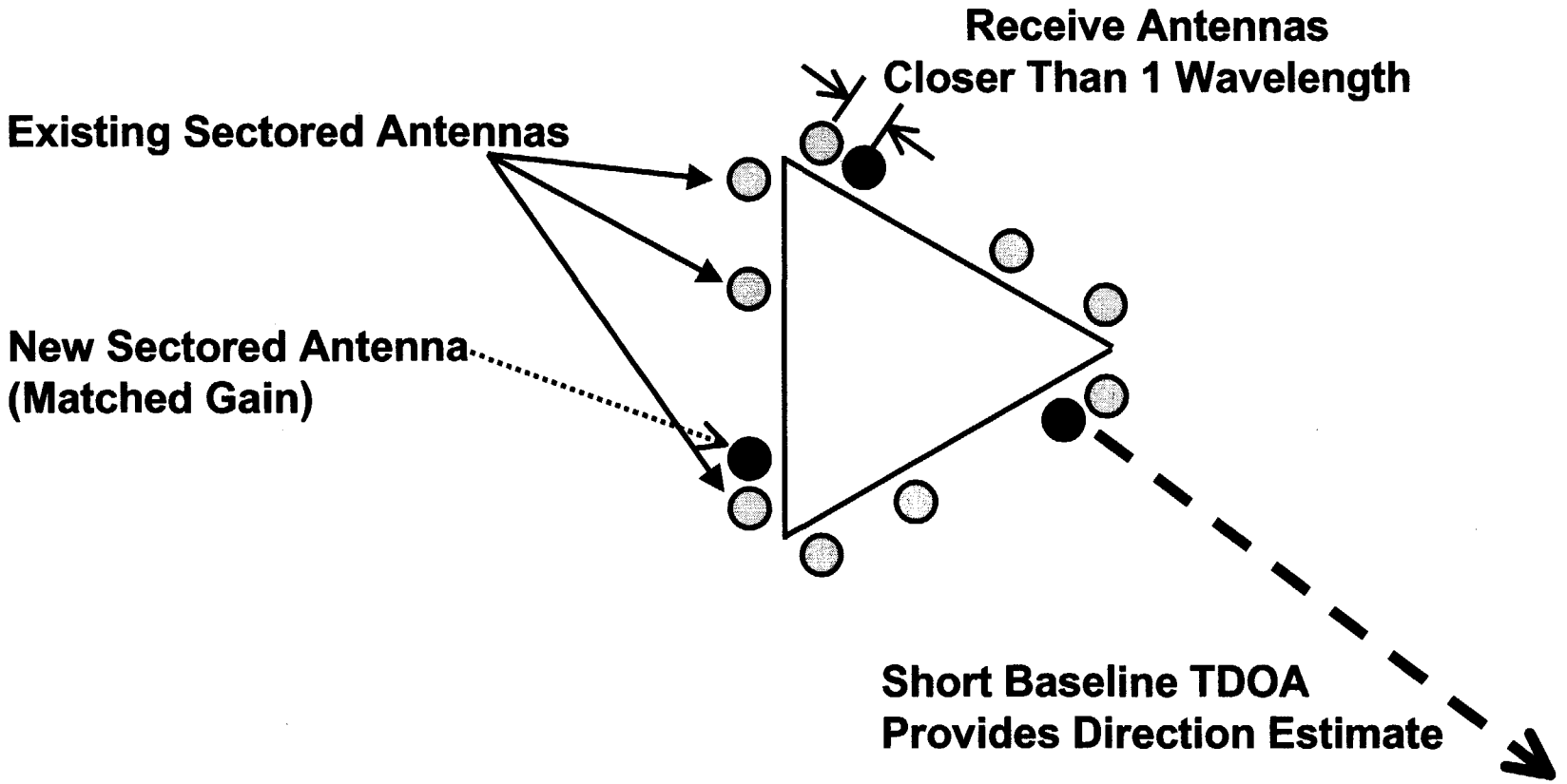
When Needed, Additional Antennas Add Direction Capability



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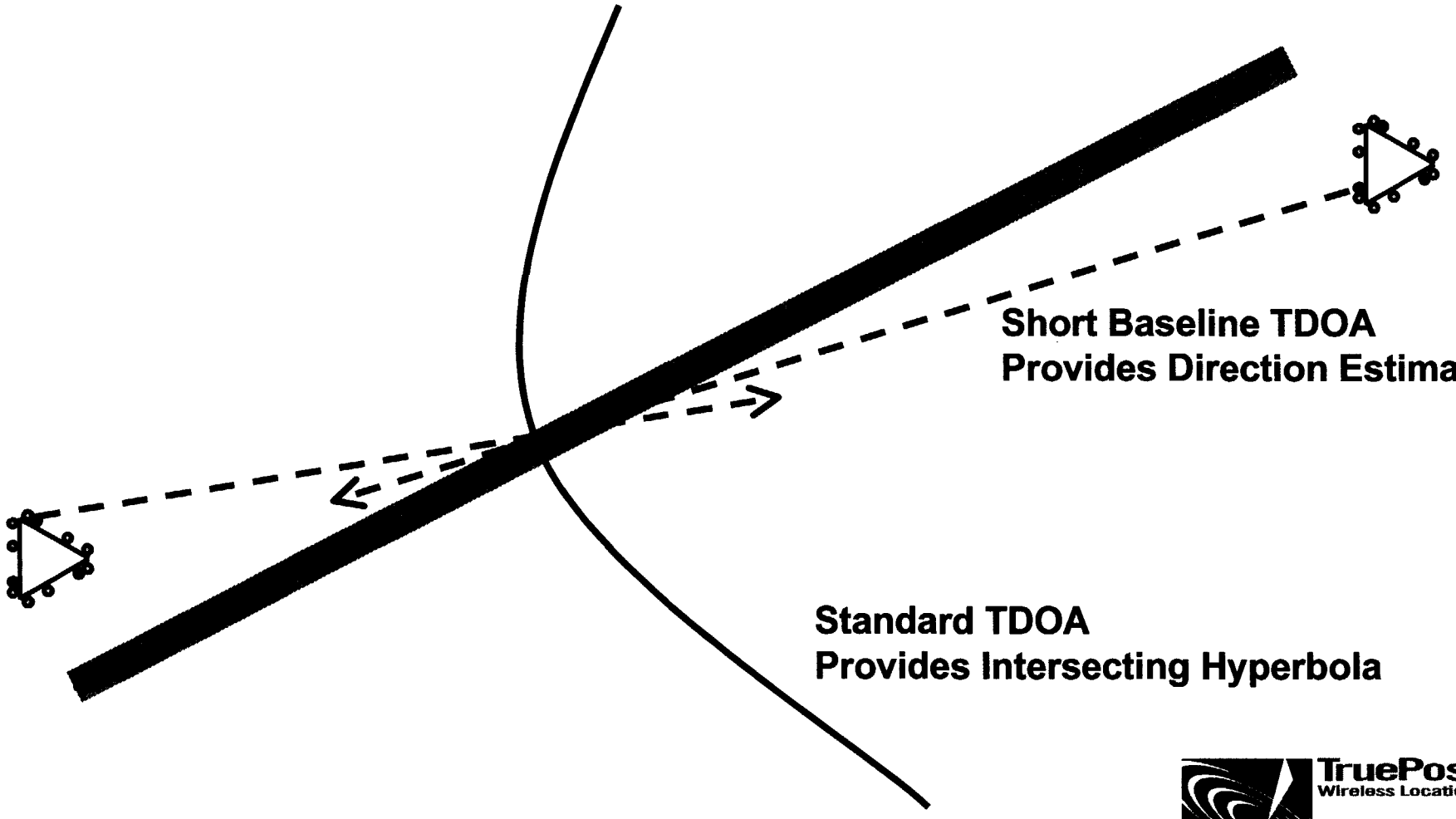
Two Site TDOA Solution For Rural Areas



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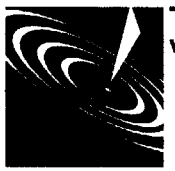
Recent Advances to Overcome CDMA Challenge

- **Problem**
  - Interference Limited System
  - Severe Power Control
  - Detection Limited at Cooperating Sites (Near / Far Problem)
  - Central Based Correlation Will Not Work Well
- **Solution**
  - Station Based Processing
  - 53 dB Processing Gain for Access Probe
- **Results From Simulations**
  - Lightly Loaded Cell Sites: 76 Meters RMS
  - Heavily Loaded Cell Sites: 84 Meters RMS
  - Modeled Using 2 Mile Cell Site Spacing (Urban / Suburban)



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Technical Risks of GPS In Handset

- **Significant Predicted Costs From Waiver Requests**
  - Development, Integration For Both Handsets *and* Networks
  - Significant Patent License Fees
  - Distribution Costs *Plus* Disposal Of Old Handsets / Batteries
- **Can Antennas Be Integrated Into Every Handset?**
  - Over 150 Handset Models From At Least 15 Vendors
- **Most Optimistic Timeframes Make First Handsets Available In 2001, Only 90% Coverage In 2005**
  - Unrealistic To Assume That No Delays Will Occur
- **Significant Standards Work To Support Functionality**
- **No GPS Signal Improvements Until 2007**

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Effect of Integrating GPS Antennas Into Phones

- **"GPS antenna handset integration will lead to significant performance loss as compared to external antennas used for prototype systems.....this work calls into question claims of reliable location coverage for in building and in vehicle situations."**

Antenna Comparisons at 87.5% Reliability Level

Antenna Type	Free Space	Phone At Head	Phone on Belt
Reference Patch	0 dBic	-	-
Patch on Phone	-	-14.0 dBic	-17.5 dBic
Dipole on Phone	-	-17.5 dBic	-24.5 dBic
Helix on Phone	-	-23.0 dBic	-30.5 dBic

Source: Motorola T1P1.5/98-348

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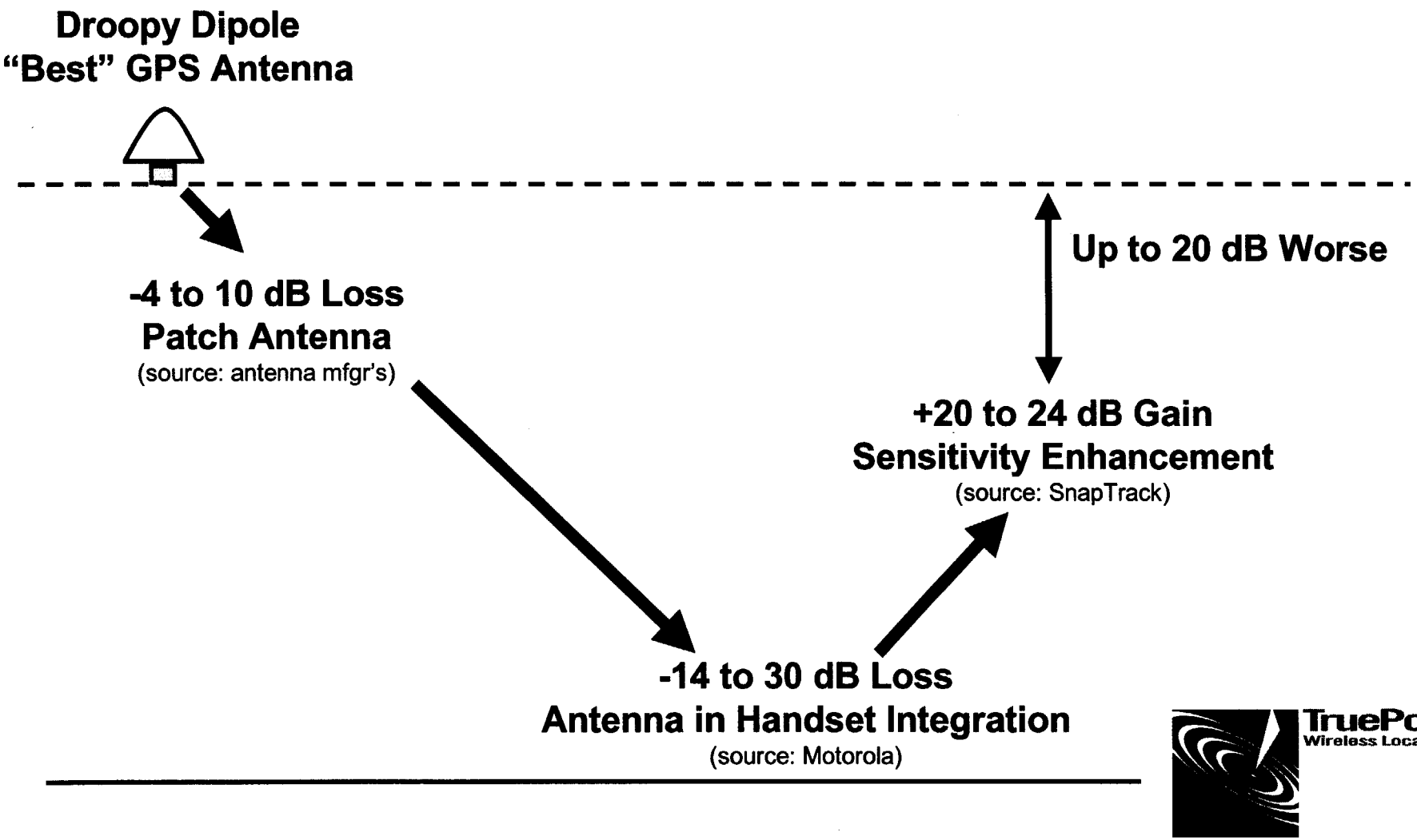
Comparison of GPS Antenna Approaches



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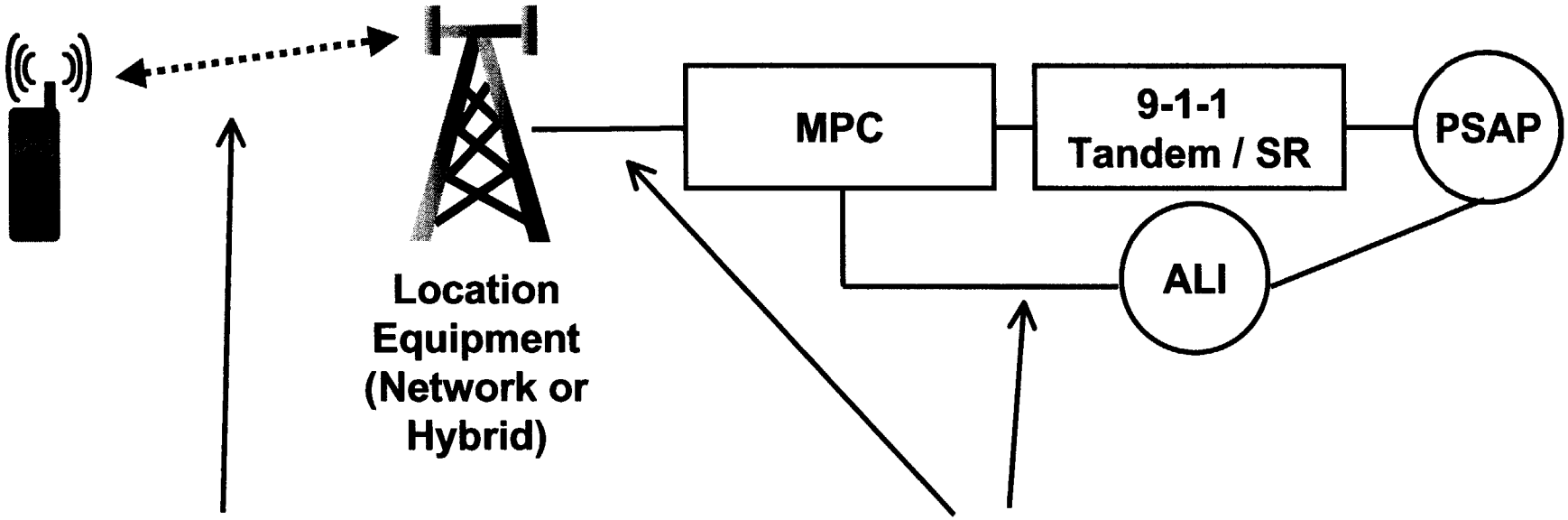
Standards Requirements (and Risks) Lower for Network Based Systems



Needed Only for Hybrid Handset/ Network to Support Signaling

TR45.1 (AMPS)
TR45.3 (TDMA)
TR45.4 (Base Station to Network)
TR45.5 (CDMA)
T1P1.5 (PCS)

Preferred for All Location Systems to Transport Phase II Data

TR45.2 (Ad Hoc Emergency Services)

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